A Comparison of Efficient Grain Production and Nitrous Oxide Emissions

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Key Points:

- Nitrous oxide (N_2O) losses appear to be minimal from dry-land low to medium rainfall farming systems; with the highest peak emissions of only 4.0 g N_2O-N/ha/day[1] measured following rainfall.
- N_2O emissions from legume stubble over summer and following synthetic nitrogen fertiliser application in-crop were all low.
- An increase in soil water was the major driver of N_2O emissions.

Project Report: Nitrous Oxide Losses from Dry-land Cropping

The use of all types of nitrogen fertiliser has increased in the last few years even in the lower rainfall districts as farmers have moved towards greater cropping intensity and become more confident in utilising stored soil moisture and nitrogen levels to predict grain yields. The greater use of nitrogen fertiliser brings both economic and environmental risks including losses of nitrogen as the greenhouse gas nitrous oxide (N_2O).

Nitrous oxide is responsible for 4.7% of Australia's greenhouse gasses, and 78% comes from agriculture (Department of the Environment, 2014), increasing the interest in reducing N_2O emissions through improved fertiliser use. It should be noted that nitrous oxide emissions come from a range of sources including nitrogen fertiliser, fossil fuel combustion and some manufacturing processes.

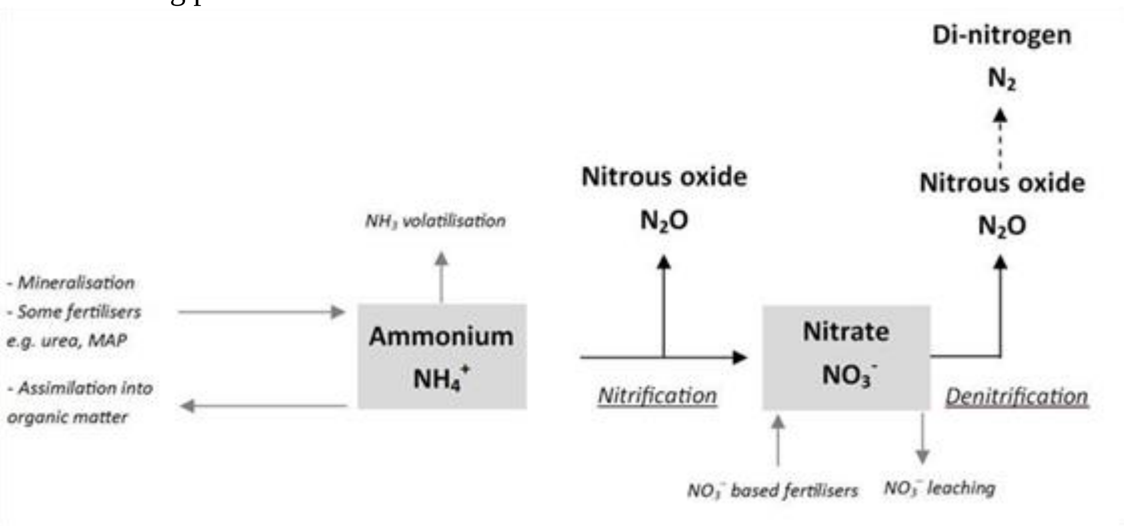

Figure 1: Two key processes (nitrification and denitrification) contributing to N_2O generation in agricultural soils. (Source: Wallace & Dowling, 2014).

The two main processes of N2O emissions in agricultural soils are nitrification and denitrification. The major factors influencing these processes are soil water content, changes in oxygen availability, soil mineral N (nitrogen), soil temperature and the availability of easily decomposed carbon (Fig 1). Warm, moist soils generally favour nitrification, while larger losses from denitrification occur with warm, wet (often waterlogged) soils.

As part of this project N_2O emissions were measured after rain in various stubbles over summer and in paddocks top-dressed with urea products in-season. These trials were conducted in low rainfall sites at Condobolin, Mildura, Birchup and Booleroo Whim. All nitrous oxide emissions were low, however emissions generally increased following rainfall, most likely due to higher soil moisture levels stimulating the soil microbes responsible for nitrification and potentially also denitrification.

Differences in N_2O emissions from various nitrogen sources (urea, polymer coated urea, ENTEC® (ammonium stabiliser) urea and Green urea) were difficult to measure because of the low emission levels produced. The highest emission recorded was 4.0 g N_2O-N/ha/day from field pea stubble in February following 69 mm at Condobolin. At most other sites emissions peaked at less than half these levels. If emissions reached a maximum of 4.0 g N_2O-N/ha/day for 365 days, annual emissions would equate to 1.5 kg N_2O-N/ha/year, however the likelihood of this occurring is low for low rainfall cropping areas. Previous studies, such as those summarised by Barton et al. (2014), indicate that emissions from various farming systems can range between 0.3 to 16.8 kg N_2O-N/ha/year, making results from this project comparatively low.

The environmental impact of N_2O is significant due to the large global warming potential of N_2O, approximately 300 times the warming potential of carbon dioxide (CO_2). In low to medium rainfall dry-land cropping, in particular sandy soils, waterlogging events are infrequent, reducing the risk of denitrification resulting in N_2O losses being very low. Other industries such as sugar cane, intensive pasture production and many horticultural industries where N inputs are far higher and irrigation is often used have significantly higher N_2O emission levels.

On-Farm Profitability

If we assume a theoretical paddock with maximum emissions of 4.0 g N_2O-N/ha/day (1.5 kgN_2O-N/ha/year) the nitrogen loss would be only $1.95/ha/year, assuming $600/tonne of urea. Despite relatively low cost, there are still opportunities to reduce emissions and increase profitability/production by altering the timing of fertiliser application and applying the best product at the correct rate.

Best management of N fertiliser application can be achieved by following the 'four R's':

- Right rate – use soil and crop testing to determine yield potential
    - Use seasonal outlooks to better estimate rainfall and yield potential
    - N-rich strips to gauge potential for crop response to N fertiliser
    - Yield Prophet® or soil moisture probes for monitoring plant available water
    - N sensors in combination with variable rate application to adjust N fertiliser rates.
- Right time – apply at Growth Stage 30 just before a significant rainfall event
- Right place – some applied pre or at seeding but most post sowing
- Right product – will depend on the type of application equipment available, cost of products and the potential for N losses.

Carbon Farming and Nitrogen Fertiliser

Greenhouse gas emissions are reported in carbon dioxide equivalents (CO_2-e) and the 1.5 kgN_2O-N/ha/year emission level is the equivalent of 702 kg of CO2-e. Even at a carbon price of $23/ha, the value of N_2O emitted from the 'theoretical farm' example used above would only be $16/ha/year. However, as mentioned above, the likelihood is emissions for low rainfall cropping systems are far lower than the 1.5 kg N_2O-N/ha/year, which would correspond to a lower cost of emissions.

Currently the potential for farmers to participate in carbon markets relating to N_2O emissions and fertiliser use in the Australian dry-land cropping industry is very limited, with generally low emissions from most of the cropping zone and particularly the low rainfall areas.

Notes

[1] N_2O-N/ha/day is the amount of nitrous oxide gas emitted from a hectare of land in a day.

References

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